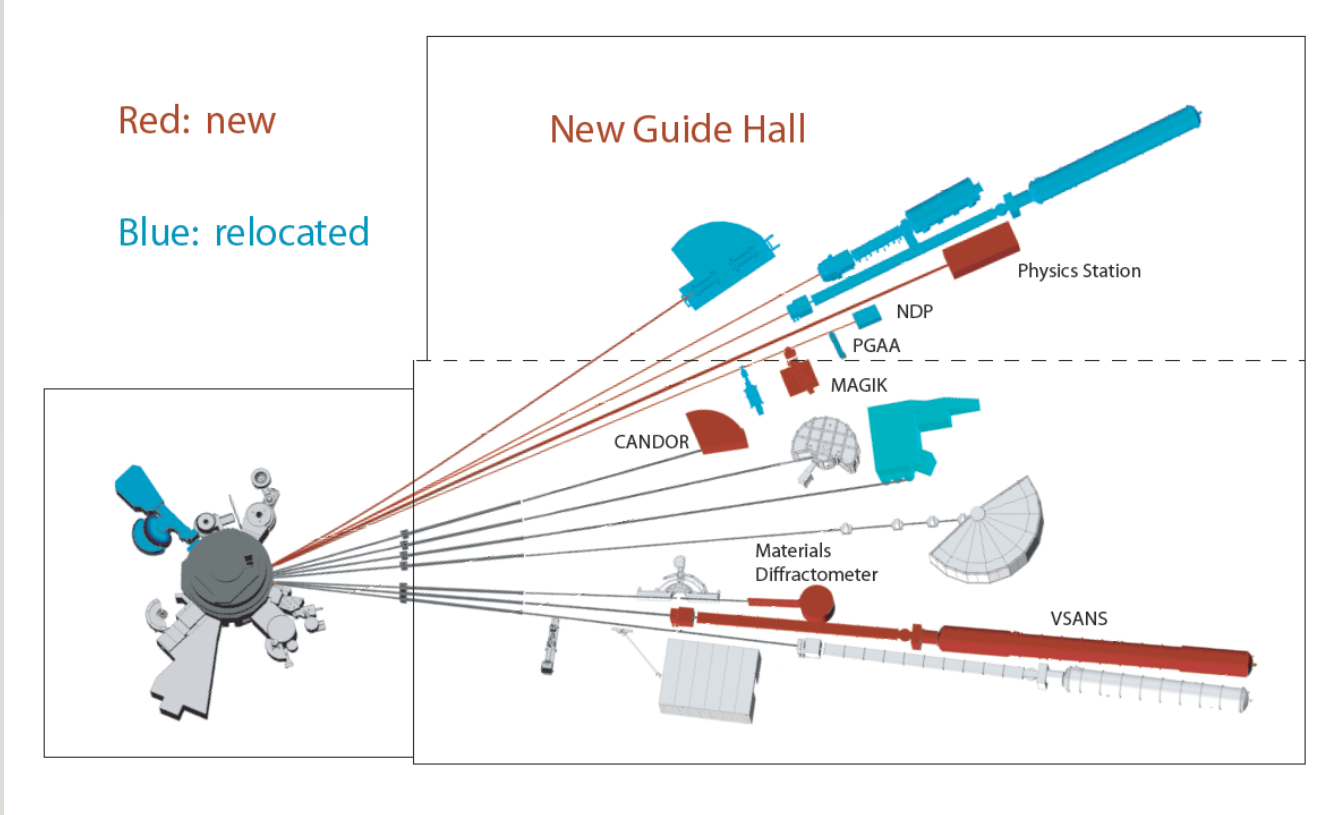


A Faster High-Temperature Closed-Cycle Refrigerator for Neutron Scattering

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Background

- Single Stage Closed-Cycle Refrigerators (CCRs) now have great cooling power and low base temperatures
- Thermometry that can withstand thermal cycling from sub-77 K to more than 600 K is limited
- Most users needing both low and high temperature are satisfied with a base temperature of 30 K or better
- Need a simple system that is easy for users to operate
- “User operated” implies more attention paid to safety in operation



Design

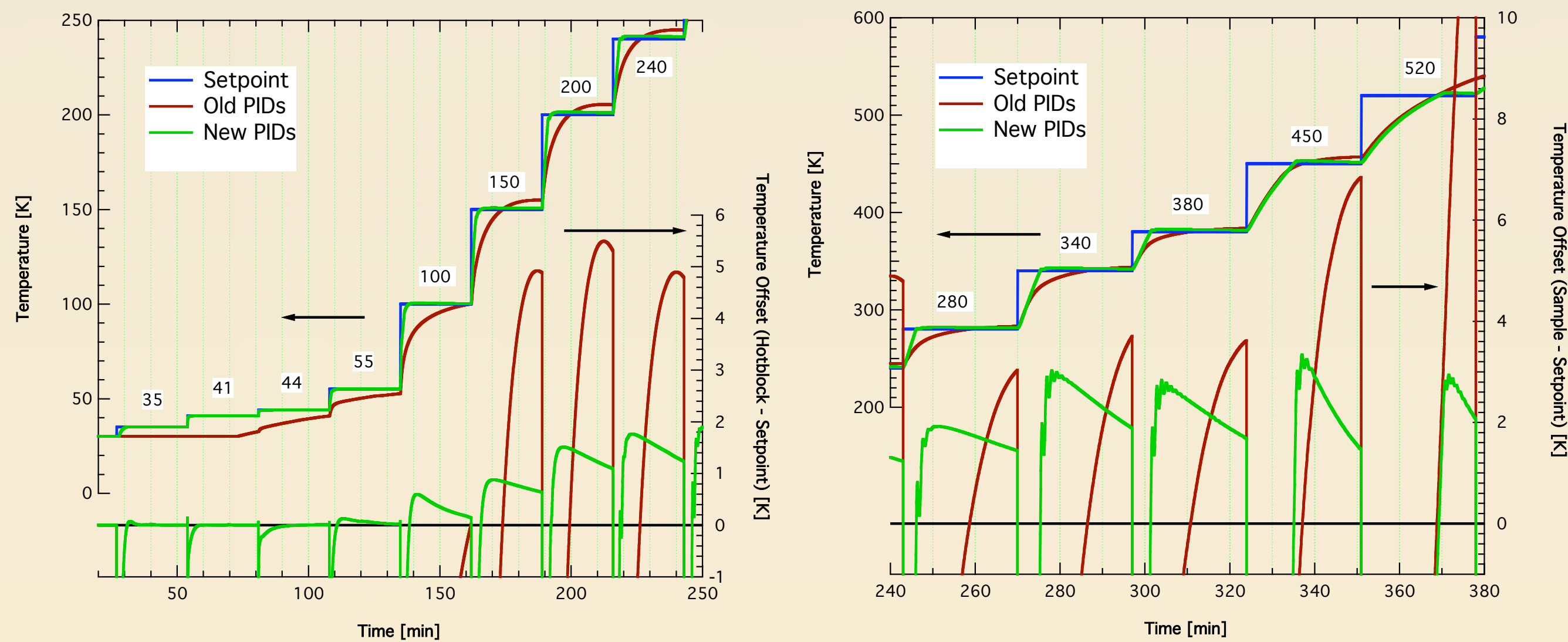
- Single stage coldhead (prototype with ARS DE-102T with “turbo” upgrade)
- N-type thermocouples for control and optional, floating sample sensor
- Extra vacuum ports for introduction of new capabilities for special experiments (gas-loading, voltage, *etc.*)
- Thinned aluminum in the beam
- Floating heat shield

First Prototype Performance

- Controlled temperature range 25 K to 850 K
- Cool down from room temperature to 25 K in 25 minutes
- Cool down increases to 25 K in 35 minutes when using smaller helium flex lines, but easier to handle
- Temperature controller needs at least 200 Watts to control throughout range
- No water cooling required
- Single heat shield design
- Outer vacuum shroud temperature was greater than 50 C (323 K) at maximum temperature (**Too Hot!**)

Safety

- Want outer vacuum shroud temperature kept below 50 C (323 K) at highest sample temperature
- Temperature control heater cuts out via independent thermal switch if coldhead gets too warm
- Temperature controller maximum setpoint limit set to prevent user error
- Outside vacuum shroud has temperature sensor strip glued on to alert user



PID Tuning

- Most temperature controllers have only a single time constant supported in their PID control loops
- We measure temperature vs. time with stepped heat loads across operational range
- Automated data collection runs for 2-3 days

- Collected data is fit to extract time constants vs. temperature
- We also obtain cooling power as a function of temperature at the same time
- With time constants vs. temperature, we can map out a PID zone table for best control at various temperatures
- We can set Integral and Derivative values of the PID control loop for each determined temperature zone
- This leaves only Proportional values to be determined by a technician for each temperature zone

Future Improvements

- Double floating heating shields to reduce outer vacuum shroud temperature
- Heat shield tied to sample mount to reduce temperature gradients
- High power temperature controller
- Try different high temperature stages for best tradeoff between heat load on coldhead and cooldown performance
- Sample temperature heat shield for temperature homogeneity

